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Optimization of Office Paper Recovery Systems

SCS Engineers, Long Beach, Calif

Prepared for

Environmental Protection Agency, Washington, D C Resource Recovery Div

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Abstract

Office building solid waste generally contains a mixture of paper grades and types which, by weight, comprise 85 to 95 percent of quantities generated. The heterogeneous nature of the paper fraction has historically discouraged wastepaper dealers from pursuing office buildings as a primary source of paper stock. Separated from the waste stream at the point of generation, however, can rid recyclable paper of prohibitive contaminants such as carbon paper, bottles, cans, and organic materials. Source separated quantities are then marketable. The study objective was to assess source separation as a viable resource recovery option in office buildings. Three basic approaches to office building source separation were studied in twelve case study locations: Desk top; dual basket; and central container.

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For the:

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1

SUMMARY AND CONCLUSIONS

Office building solid waste generally contains a mixture of paper grades and types which, by weight, comprise 85 to 95 percent of quantities generated. The heterogeneous nature of the paper fraction has historically discouraged wastepaper dealers from pursuing office buildings as a primary source of paper stock. Separated from the waste stream at the point of generation, however, can rid recyclable paper of prohibitive contaminants such as carbon paper, bottles, cans, and organic materials. Source separated quantities are then marketable.

The study objective was to assess source separation as a viable resource recovery option in office buildings. Three basic approaches to office building source separation were studied in twelve case study locations:

Desk top - provision of a small desk top container to each employee for isolation of source separated paper.

Dual basket - provision of a second "wastebasket" to each employee with one basket designated for source separated paper.

Central container - large containers conveniently placed throughout an office building to which employees carry source separated paper.

Regardless of approach, source separation of recyclable paper was performed by individual office workers on the accepted premise that employees will voluntarily contribute small amounts of time daily to a separation task without interruption of work routines or infringing on overall office productivity.

Economics

Although source separation programs had positive economics, there was significant variability from program to program. Major independent variables included method of separation, type of paper separated, type of building and configuration, building occupancy status (own/lease), and custodial status (employee/contract). Overall, however, the following economic conclusions can be drawn:

Source separation is practicable and economically viable in office buildings. Overall solid waste management costs were effectively reduced by up to 50 percent with the average reduction being 17 percent.

Startup costs averaged about 5 cents per employee and entailed expenditures for initial publicity/education, equipment, and, to a lesser extent, labor.

- Publicity/education costs averaged 11 cents per employee of which 3 cents were out-of-pocket expenditures for materials.
- Incremental equipment costs were site specific, but averaged about one cent per employee.
- Incremental labor costs at program inception were also site specific and dependent on the ability to absorb the paper collection function in ongoing activities. Using monthly incremental labor costs as a proxy for startup costs, initial expenditures ranged from nothing at seven case study sites to an average of one cent per employee per month at the other five sites.

Program management was absorbed into existing workloads, i.e., no out-of-pocket costs. Administrative activities at program inception ranged from 5 to 100 hours and averaged about 120 hours (equivalent to 3 minutes per employee) of which about 100 hours were absorbed by administrative personnel and about 20 hours by clerical employees. Ongoing program management required from 2 to 110 hours per month and averaged about 25, equally split between administrative and clerical personnel.

Performance

Publicity/education at the onset and during a source separation program is an absolute necessity to attain employee participation and minimize contamination.

Employee response to source separation was immediate and rapidly became habitual.

Source separation programs attained high employee participation rates. Voluntary employee participation was as high as 95 percent and averaged 80 percent.

Source separation can divert substantial portions of office building solid waste from disposal. Diverted quantities were as high as 78 percent and averaged 18 percent.

Source separation programs were able to constrain contaminating materials to acceptable levels. Programs with the highest participation rate and the lowest contamination levels exclusively source separated white high-grade paper (computer tab cards, computer printout, and white ledger).

Recommendations

Based on 12 case studies of alternative source separation approaches and paper recovery schemes, the desk top version with exclusive separation of white high-grade paper is recommended for implementation at office buildings. Compared to alternative approaches, the recommended approach:

- Reduced effective solid waste management costs to the greatest extent.
- Incurred the lowest startup costs.
- Achieved the highest employee response.
- Experienced the lowest level of contamination.
- Incorporated the easiest into normal office routines.

II

INTRODUCTION

Gathering, analyzing, distributing, and/or preserving information by businesses and government agencies has recently increased the demand for high grade paper beyond domestic supply capacity.

With a flourishing economy in the 1960's, paper demand was met by large, small, and specialized paper mills. During 1969 and 1970, however, total output dipped and operating ratios fell to about 90 percent of capacity. The demise of small and/or specialized paper companies followed. Shortly afterwards, several inhibiting factors compounded the paper production situation. Price controls in the United States caused a low rate of return on paper sold domestically. Low profits discouraged capital expansion and, as demand for more paper climbed, many companies were caught with inadequate capacity. Pollution abatement devices, necessary under federal and local laws, necessitated unplanned capital expenditures and generally increased operations costs. Shortages such as raw materials for pulp, chlorine for bleaching, caustic soda for pulp processing, and starch for stiffness further compounded difficulties of American paper manufacturers. Uncertainties caused by the energy crisis and concern over the economy also created reluctance regarding promises on future deliveries to meet business demands.[1]

The result of demand exceeding supply will become increasingly critical unless remedial conservation action is taken and paper control measures adopted by business firms. Control could be achieved in one of two manners:

- Recycling of used paper products, and
- Source reduction.

This report focuses on the recycling alternative as applied to paper from office buildings.

The type of paper generated in office buildings primarily consists of four categorical grades: mixed, newspaper, corrugated, and pulp substitutes/high grade deinking stock which by weight can comprise over 80 percent of office building solid waste. Outwardly, this would appear to qualify office buildings as a primary source of recoverable paper

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supply. However, a 1970 survey of the paper stock industry by the National Association of Recycling Industries, Inc. indicated that only one of four paper stock dealers handled paper from office buildings. This low rate is likely attributable to dealers focusing on generators with high volumes of homogeneous grades of relatively uncontaminated paper versus office buildings generating heterogeneous paper wastes which cannot be directly reused in high grades manufacture without some degree of separation. If source separated into homogeneous grades, however, the discarded product would be more desirable and have greater market ability than in a mixed state. It was with respect to the unquantified aspects of office building source separation that the U.S. Environmental Protection Agency contracted with SCS Engineers to obtain detailed information on the performance and costs of operating these resource recovery programs.

This report presents the results of 17 case studies performed on representative source separation programs throughout the nation. The relationships developed and presented herein should be helpful to [illegible] in the [illegible] and [illegible] of source separation programs. The [illegible] encompass assessment of recycling mill capacity to absorb additional quantities of source separated office paper.

SOURCE SEPARATION OPERATIONS

Operation

Source separation of recyclable paper in an office building should be considered a subsystem of an ongoing solid waste collection system. Twelve source separation programs were studied to obtain operational and cost information. This section presents an assessment of the operational aspects.

The source of motivation and reasons for implementing the twelve programs studied are summarized in Tables 1 and 2. Program motivation was primarily from the management echelon although employee impetus had a significant bearing on many of the sites visited. One program was initiated in response to a legislative mandate.

Ninety-two percent of the case study locations cited ecology as the reason for starting a paper separation program. Interrelated responses of waste disposal cost reduction and financial profit were the second most prevalent reasons given for program initiation. A significant 67 percent of the case study sites used separation programs to create employment opportunities.

Table 1 provides descriptive information on the case study sites. The buildings studied were located throughout the nation and selected from three types of office buildings:

- [illegible] buildings including two [illegible] insurance companies.
- [illegible] buildings encompassing two state [illegible], two communication companies, and a federal government office complex.
- [illegible] buildings including a manufacturing firm, a university, and a building housing tenants from a cross-section of business types.

The number of employees at the case study locations ranged from 650 to 9,000 with median employment being 1,800. The number of individual buildings at case study sites ranged from a single building to as many as 70.

Total solid waste generated at the case study sites ranged from 15 to 700 tons per month with median generation being 67 tons per month.

[illegible]

[illegible]

[illegible]

All case study sites had conducted source separation programs for a minimum of one year. The average program had been in existence about three years, the most enduring being seven years.

In addition to selecting case study sites with respect to type of business, source separation approach was an important criterion. Three basic approaches to office building source separation were studied:

- Desk-top* - Each employee working at a desk is provided with a small container (Figure 1) for the purpose of holding separated paper. Collection of the separated paper can be performed in several manners which will be discussed in a subsequent portion of this section. The remaining solid waste is disposed in a wastebasket on the floor and collected for disposal in a conventional manner by custodians. Three desk-top programs were studied.

- Dual Basket - Each employee is provided with two baskets, one for recyclable paper and one for all other solid waste (Figure 2) whereupon the custodial staff independently or simultaneously collects the contents of each. Three dual basket programs were included in the analysis.

- Central Container - Desk employees separate paper and accumulate it in a receptacle of their own discretion (desk drawer, one shelf of an "in-out" circulation basket, etc.). Again at personal discretion, accumulated paper is carried to a container centrally located for a number of employees.

* As studied, the desk-top approach to source separation is offered by Shade Information Systems, Inc. Shade is a private firm basically involved in the manufacture and sale of office paper (bonded ledger, computer printout, carbonless forms and bond made from recycled paper). Within the last two years, Shade developed a complete desk-top office paper separation program that has been offered to customers and other interested companies as an ecologically advantageous and cost-effective recycling system. The "Waste-Not" program includes provision (at no direct charge) of all necessary desk-top containers, initial promotional/educational materials, and transportation of separated paper from office complex to paper stock dealer. The program, as operated, accepts white paper only (tab cards, printout, and ledger) and has been implemented in over 100 office buildings.

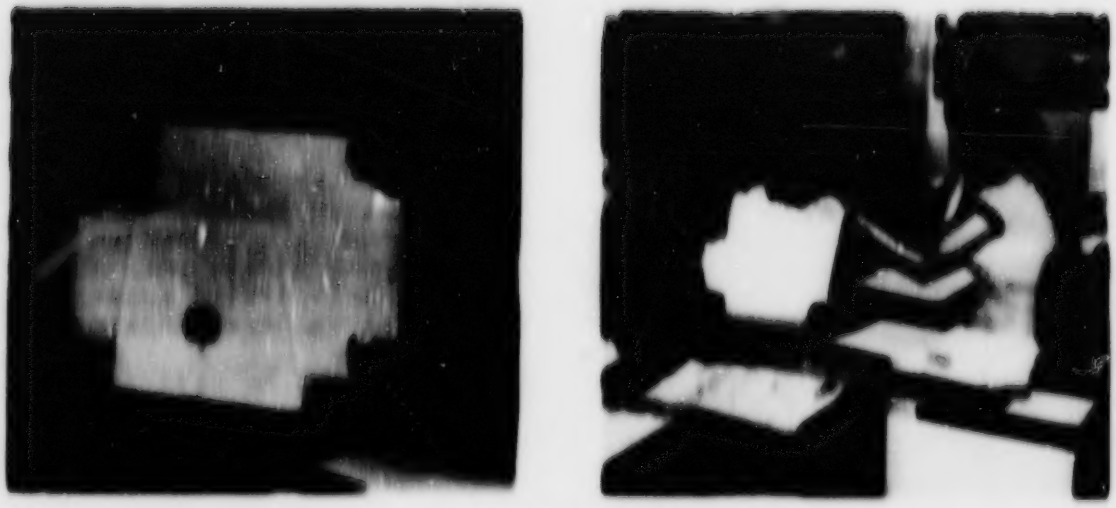


FIGURE 1. Typical desk-top container

FIGURE 2. Typical dust gasket configuration

(figure 3). The central container approach is also used in departments where employees are not "desk oriented," and large quantities of uncontaminated paper are generated (e.g., computer rooms, filing rooms). All other solid waste is placed in waste baskets and conventionally handled. Six central container programs were selected for case study.

As indicated in table 3, all twelve sites relied on employees to perform the initial source separation task, that is, separate desirable paper from office waste. Three case study sites conducted secondary sorting (i.e., post-employee sorting) to remove residual contaminants and to separate by grade the paper recovered via initial employee separation.

Two case study sites (Buildings No. 1 and 4) restricted employees from eating lunch at their desks so that paper contaminants such as bottles, cans, organic lunch wastes, etc. did not enter desk waste baskets. Without these contaminants, both case study sites were able to fully or partially market unseparated office waste as a low grade paper mix. All other case study sites conducted "skimming" operations whereby only the materials reclaimed through employee separation efforts were marketed.

The paper quantity and grade(s) separated at each case study location are shown in the last set of columns in table 3. Computer tab cards were generally isolated from other waste paper grades due to having the highest market value. Computer printout was generally included with white ledger unless a high degree of secondary sorting was performed. Similarly, colored ledger, unless secondarily sorted, comprised a mix of white and colored ledger. Newspaper was separated at two case study locations and corrugated at one. A mixed grade of paper was source separated at five locations. The cumulative quantities separated at the 17 case study locations ranged from 3 to 175 tons per month.

Solid Waste Management Activities

The activities associated with managing solid waste from the point of generation through disposal are defined as unit processes. The unit processes associated with typical office building solid waste management are diagrammed in figure 4. As seen, the only significant unit process variation between a system designed to collect and dispose all solid wastes generated and that to recover recyclable paper from the waste stream is source separation. Thus, many of the unit processes associated with a source separation program have potential for integration with ongoing waste management activities. Integration, however, must consider

Wheeled container

Fiber Barrel

Figure 1. Typical control containers

the potential for paper contamination if not properly conceived and implemented. For example, receptacles on the floor (baskets, boxes, central containers) can have a "waste connotation," while elevated receptacles have a "recovery connotation."

Parameters associated with incorporation of a source separation subsystem are discussed below based on the methods used at the twelve case study locations.

Office Waste Characteristics

Solid waste characteristics such as generation rate and composition are rarely the same from location to location. Office buildings are no exception.

Attempts were made to correlate waste generation rate with such variables as number of employees (aggregate and by administrative/clerical job categories), useable floor space, and paper generating facilities (print shop, reproduction, computer). Short of multiple regression analysis which was beyond the scope of this study, the aggregate number of employees was determined to be the variable most highly correlated with office building waste generation. Table 4 presents the relationships developed by building type. As shown, bank/insurance company buildings had solid waste generation rates ranging from 0.90 to 4.40 lbs per employee per day, and categorically averaged 2.11 lbs per employee per day. General office building employees generated from 0.72 to 3.14 lbs of solid waste per day and averaged 1.65 lbs daily. One noteable observation associated with the preceding ranges is the source reduction practices conducted in conjunction with source separation at the two case study sites with the lowest generation rates:

> Building No. 1 (0.90 lbs per employee per day) reduced paper consumption/waste generation by using both sides of computer printout paper.
>
> Building No. 6 (0.72 lbs per employee per day) instituted a paper reduction/conservation program with the aid of a reproduction machine company.

The building types included in the multi-disciplined category were too diverse to develop meaningful generation ranges or an average.

Waste composition also varies by business type. Table 5 presents the results of representative waste sampling conducted at three bank/insurance companies (Buildings No. 1, 7, and 11) and three general office buildings (Building

TABLE 4

EMPLOYEE SOLID WASTE GENERATION BY BUILDING TYPE

Building Type/ Number	Office Employees* (no.)	Building Solid Waste Generation (lbs/day)	Average Employee Generation Rate (lbs/employee/day)
Bank/Insurance			
1	9,000	21,820	2.42
2	990	4,450	4.49
3	1,700	1,540	0.90
4	2,250	5,160	2.29
Average	--	--	2.31
General Office			
5	1,040	2,270	2.18
6	2,000	1,450	0.72
7	7,440	10,730	1.44
8	6,040	14,730	2.44
9	1,000	5,910	5.14
Average	--	--	1.55
Multi-Disciplined			
10	550	4,100	7.40
11	1,200	8,090	6.74
12	7,000	9,540	1.36
Average	--	--	5.23

* Office workers only, does not include field personnel

TABLE 5

COMPOSITION OF OFFICE SOLID WASTE
BY BUILDING TYPE*

	Generation/Building Type (lbs/employee/day)					
	Bank/Insurance Co.			General Office		
Material	Range	Average	%	Range	Average	%
Paper						
Computer fan cards	0.28-0.51	0.39	17	0.02-0.11	0.05	3
Computer printout	0.60-0.74	0.70	30	T-0.17	0.11	7
White ledger	0.67-0.74	0.70	30	0.31-0.62	0.51	33
Colored ledger	0.05-0.16	0.12	5	0.05-0.13	0.09	6
Newspaper	T-0.16	0.07	3	0.19-0.36	0.25	16
Corrugated	0.05-0.07	0.05	2	0.11-0.17	0.14	9
Other[a]	0.11-0.16	0.14	6	0.18-0.22	0.17	11
Garbage	T-0.07	0.02	1	0.05-0.12	0.09	6
Metal	0.02	0.02	1	0.02-0.05	0.03	2
Glass	T-0.04	0.02	1	T-0.06	0.03	2
Plastic	0.02-0.05	0.02	1	0.02-0.09	0.05	3
Textile	T-0.02	0.02	1	T	T	T
Wood	T-0.02	0.02	1	T	T	T
Miscellaneous	T-0.02	0.02	1	T-0.06	0.03	2
Total	---	2.31	100	---	1.55	100

* Based on representative solid waste sampling conducted at the buildings during study; does not include cafeteria waste

T Trace

a Generally non-recyclable paper: carbon paper, wax coated or impregnated paper products, etc.

No. 9 and references No. 4 and 5).* As shown, paper is predominant with recyclable grades totaling 87 percent by weight in bank/insurance companies, 74 percent in general offices. In each instance the greatest portion of the recyclable paper was represented by white high grades (tab cards, printout, and ledger) which also command substantially higher market prices than colored ledger or the low grades represented by newspaper, corrugated, and 'mixed' (see Appendix A). By building type, white high grades generated in a bank/insurance company ranged from 1.55 to 7.01 lbs per employee per day and averaged about 1.70 lbs per employee per day. Corresponding figures for general office building were daily employee generation rates ranging from 0.31 to 0.90 lbs with an average of 0.47 lbs. Greater use of computers and the resulting generation of tab cards and printout accounts for the major differences.

Source Separation

Source separation is the only activity not contained in an ongoing solid waste management system designated for collection and disposal. As practiced, initial separation of desirable paper from the waste stream does not require additional personnel. All twelve case study sites relied on employees to perform the initial separation task. This practice was based on the premise that employees will voluntarily contribute small amounts of time daily to paper separation without interruption of regular work routines or infringing on office productivity. Adequate initial and ongoing administration, including a publicity/education program is required to gain positive employee response in terms of participation and proper separation/preparation.

Program Administration. Proper planning at program onset was universally stated as being necessary to implement a successful source separation program. Initial efforts fell into two basic groups: (1) administrative tasks (e.g., assessing collection labor alternatives, designating container locations, negotiating paper purchase contracts, etc.), and (2) publicity/education. Initial administrative and clerical labor to accomplish these efforts are delineated by building type and source separation approach in Table 6. Due to many case study site variables, each categorical tabulation contains a significant range of requirements although with the exception of Building No. 11, all time was absorbed into existing workloads. Overall, initial

* Sampling not conducted at multi-disciplined case study site due to building type/solid waste diversity.

[redacted]

administrative and clerical efforts ranged from a low of 5 hrs to a high of 180 hrs with a 12 case study average of 117 hrs. Computed in terms of time per employee, the range was less than one minute to almost 13 minutes, with an average of about 3 min per employee.

Ongoing administrative and clerical requirements are summarized in Table 7 with respect to building type and source separation approach. Ongoing program management required from 0 to 110 hours per month and averaged 24 hours per month. These labor requirements were also absorbed with the exception of Building No. 11. Of the data presented in Table 7, the most significant are the minimal ongoing administrative requirements associated with the desk top (1 hr per month) and central container (9 hrs per month) approaches. Larger ongoing administrative requirements associated with the dual basket approach (80 hrs per month) may be more attributable to the multiple building aspect of the three case study sites than to the approach (10, 16, and 10 individual buildings respectively for Buildings No. 7, 8, and 11).

Publicity/Education. Case study locations used a wide variety of initial publicity/education approaches including video tape presentations, posters, memos, leaflets, company newsletters, etc. Program announcement and associated publicity preceded the implementation date by about a month and outlined program goals and objectives. Publicity also included a description of the approach used and delineated acceptable and unacceptable paper grades or other materials, the latter being a critical point.

In that employee participation was stated as being habitual and absorbed in employee working habits very quickly, ongoing publicity/education efforts generally documented program accomplishments and reminded participants of the need to adhere to paper preparation requirements.

All twelve case study sites provided estimates of initial and ongoing publicity/education expenditures. Table 8 presents the aggregated administrative, clerical, and material costs for these efforts. Initial publicity/education costs for the twelve sites averaged 11 cents per employee with a range of 1 to 28 cents per employee. The only out-of-pocket costs were for materials; administrative and clerical costs were absorbed in each case. As a rule of thumb, material costs generally accounted for 70 to 90 percent of the expenditures listed in Table 8 for initial and ongoing efforts.

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]					
[illegible]	[illegible]					
[illegible]	[illegible]					
[illegible]	[illegible]					

TABLE 8

INITIAL AND ON-GOING PUBLICITY/EDUCATION COSTS*

Building Type/ Number	Publicity/Education Costs*		Total Employees (no.)	Cost per Employee	
	Initial ($)	On-Going ($/mo)		Initial ($)	On-Going ($/mo)
Bank/Insurance					
1	520	70	9,000	0.06	0.01
2	90	40	1,200	0.08	0.03
3	650	0	1,700	0.38	0.00
4	700	12	1,700	0.39	0.01
General Office					
5	850	10	1,200	0.72	0.01
6	2,000	20	2,000	0.95	0.01
7	230	60	7,500	0.03	0.01
8	250	0	6,000	0.04	-0-
9	1,000	160	7,000	0.14	0.00
Multi-Disciplined					
10	30	10	550	0.05	0.02
11	250	250	1,400	0.18	0.18
12	770	30	7,000	0.11	0.01
Overall Average	470	60	3,500	0.13	0.02

*Administrative, clerical and materials costs.
-Rounded to nearest $10.

Articles in company newsletters were the basic form of ongoing publicity. Costs for the ongoing efforts averaged [illegible] cents per employee per month with little variation in average expenditures per employee per month.

[illegible] Project coordinators at each case study [illegible]ed that response to source separation was immediate and rapidly became habitual for employees who chose to participate in the paper separation programs. Table 8 presents employee participation rates by building type and source separation approach as estimated by the respective project coordinators. With the noted exceptions, four out of five employees were estimated to continually participate in the average paper recovery program.

Although there are variations by building type, the more significant comparisons are between the source separation approaches. The average desk top program attained a 90 percent participation rate. Central container and dual basket programs received significantly lower participation rates of 78 and 77 percent, respectively. There are three possible explanations for this disparity.

[illegible] Although representing a wide [illegible] and other independent variables, initial publicity/education cost per employee (from Table 8) appear to correlate with participation rate.

Approach	Participation Rate	Publicity Expenditures ($/employee)
Desk top	90	0.27
Central container	78	0.14
Dual basket	77	0.06

[illegible] The desk top programs [illegible] only white grades of paper which are easily discernable by an employee (computer tab card, computer printout, white ledger). Dual basket and central container programs generally sought to recover multiple grades which requires employees to make further distinction between grades.

[illegible] Placement of separated paper in a desk-side container is more convenient than a basket on the floor or a central container.

[illegible] In view of office building waste composition, paper and, depending on business

TABLE 6

EMPLOYEE PARTICIPATION RATE*

- By Office Building Type -		- By Source Separation Approach -	
Building Type/Number	Participation Rate (%)	Approach/ Building Number	Participation Rate (%)
Bank/Insurance		Desk Top	
1	75	1	80
2	10**	5	95
3	80	10	95
4	63	Average	90
Average	77	Dual Basket	
Category[1] Office		7	67
5	95	8	70
6	61	11	85
7	67	Average	77
8	70	Centre[2] Container	
9	85	1	75
Average	77	2	10**
Multi-Storey/Mixed		4	63
10		6	61
11	95	9	80
12	80	12	-
Average	-	Average	70
Overall Average	80	Overall Average	80

*Not included in averages. Program concentrated in areas with few employees/ heavy wastepaper generation; efforts to increase building-wide participation were being instituted at time of case study.

**Estimate of participation not available.

[1]Categorical averages may not be conclusive due to limited number of case studies and multiple independent variables.

type, white paper averaging from 61 to 77 percent of the paper component (refer to Table 6) there are two categorical options to consider when planning a source separation program:

- Maximize paper recovery by separating all recyclable grades.
- Maximize revenue by separating high grade paper only.

Within each of these options, consideration must be given to (1) marketing the separated quantities in the employee-separated condition, or (2) to further sort employee-separated paper and market by specific grade. As summarized below, seven case study sites sought to maximize recovery, thus minimizing paper revenue; five to reduce disposable waste through simplicity to maximize paper revenue. Nine of the twelve buildings marketed paper separated by employees with little or no secondary sorting while three sites conducted major secondary sorting operations to improve marketability.

Source Separation Objective	Number of Case Study Sites
Maximize recovery/Minimize paper revenue	
Employee separated only Secondary sort	9 3
Reduce disposal/Maximize paper revenue	
Employee separated Secondary sort	4 1

Once the grade of paper to be source separated has been selected, adherence to paper stock specification(s) is imperative for market acceptability. Specified contamination levels, which are expressed in terms of weight, generally range from one percent in high grades to ten percent in low grades. Accordingly, employee education must dwell on the importance of proper separation/preparation so that two consequences are minimized:

- A secondary sort is either not required or can be readily performed with minimal effort.
- Separated quantities are not downgraded and lower revenue received due to the necessity for a paper dealer to resort prior to mill acceptance.

Table 10 presents the estimated contamination level of source separated paper at the case study sites in terms of

[illegible]

[illegible]

[illegible]

building type, approach, and type of paper separated. Based on variations by approach, desk top programs, which separated white paper only, had an average post-employee contamination level of three percent, or about one-third that of the dual basket or central container programs which averaged nine and eight percent, respectively. The relatively low contamination level of desk top programs may be attributed to a combination of two previously mentioned factors: (1) highest categorical expenditures in employee education, and (2) source separating white paper only. A third, unquantifiable factor of having the container for placement of separated paper on the desk (value connotation) versus on the floor (waste connotation) may also have been influential.

Case study sites using dual basket or central container approaches generally sought to maximize paper recovery by source separating a mixed grade for marketing or secondarily sorting into specific grades prior to marketing. Source separation of a mixed grade in Buildings No. 1, 2, 7, and 11 was apparently interpreted by employees as acceptability for all paper grades which resulted in post-employee contamination levels ranging from 10 to 21 percent. Secondary sorting was conducted at three of the four buildings to remove contaminating materials which were predominantly newspaper and carbon paper. The five remaining dual basket/central container programs had contamination levels paralleling those of the desk top approach which indicates operational stability. Nonetheless, the need for intensive employee education is essential when striving to separate a mixture of paper grades.

Post-employee contamination levels achieved versus paper stock dealer acceptance levels (refer to Appendix A) are summarized below on the basis of paper grade separated at the case study sites:

Grade	Acceptable Contamination (%)	Case Study Site Contamination (%)
White only	1	3
White, colored	5	8
Mixed	10	9

As shown, contaminants in white only programs exceeded the acceptable specification. Conformance to acceptable white ledger requirements necessitated minimal sorting which was generally accomplished by collection personnel.* Mixed

* As practiced, contaminants were easily spotted by collection personnel when the desk top approach was used.

ledger (i.e., white, colored) programs far exceeded acceptable contamination levels while mixed (i.e, high-low grade mix) programs were within acceptable levels.

Diverted Disposal. The amount of paper diverted from total solid waste disposal averaged 19 percent by weight in the 12 case study sites. Individual and categorical diversion rates are cross-tabulated in Table 11 by business type, source separation approach, and paper grade separated.

The average bank/insurance company building was able to divert 60 percent of their office waste through paper separation. Correspondingly, general office buildings were able to divert an average of 7 percent while the multi-disciplined buildings diverted an average of 11 percent. By using categorical waste sampling data from Table 5 as a proxy for maximum potential recovery, the effectiveness rating for bank/insurance companies was 76 percent and 60 percent for general office buildings (no sampling data were available for multi-disciplined office buildings).

Business Type	Paper in Waste (%) Available	Recovered	Recovery Effectiveness (%)
Bank/Insurance	80	99	76
General Office	68	77	60

In part, the high effectiveness rating in bank/insurance companies is due to "natural" paper separation functions induced by policies for record retention, periodic file purging, and highly computerized business management operations. These functions generate large quantities of paper amenable to source separation.

Categorically, desk top and central container programs had diversion factors of 18 and 40 percent, respectively. In terms of effectiveness, however, desk top programs would rate an edge due to recovering similar quantities from less available material. That is, the desk top programs sought only to recover white paper which comprise a lower portion of the total solid waste stream than central container programs which sought to recover multiple grades. The

* Bank/insurance company and general office building categories included a mix of source separation approaches, custodial arrangements, paper types, etc. Thus, business type was deemed to be the key variable in explaining recovery effectiveness.

* Recyclable portion only.

[redacted]

diversion rate for dual basket programs was considerably less at 18 percent.

Assessing diverted disposal in terms of paper grade also yielded significant findings. Two case study sites (Buildings No. 1 and 4) opted to maximize recovery by implementing central container programs to recover mixed high grades in conjunction with policies not allowing employees to eat at their desks. The "desk waste" was then entirely marketable as a low grade mix at Building No. 1 and partially marketable at Building No. 4. This total system approach resulted in the average diversion rate of 77 percent as indicated in the "white, colored, mixed" grade category on Table II. Of the remaining ten locations which conducted skimming programs, the three programs recovering "white paper only" via the desk top approach were the most effective, diverting 18 percent of total waste. The three programs constrained to "white and colored" diverted an average of 26 percent of the total solid waste from disposal while the four programs designed to maximize recovery through separation of a low grade mix diverted only 18 percent.

Summary. Based on the operational parameters of participation, contamination, and diverted disposal, and acknowledging independent variable uncertainties, the desk top approach was found to be decisively favorable to the dual basket or central container approaches as a means of skimming recyclable paper. The total recovery approach used by two case study sites was very effective although conditions for employee participation (adequate lounge and cafeteria space) and a market available for low grade mix are necessary for implementation.

On-Site Storage

Mixed Waste. Storage of mixed waste at an individual desk or in an area occupied by several non-desk oriented employees (computer room, file room, print shop) was consistent at all case study locations. "Desk employees" were each issued a 7.5 gal wastebasket to discard used materials. Areas such as computer rooms received one or more 20 to 50 gal containers depending on the number of "non-desk employees" and the inherent waste generating activities.

Separated Paper. As previously defined, three approaches to on-site storage of separated paper were assessed at the case study sites:

The desk top approach entailed use of a small desk top container for storage of source separated paper.

In addition, cardboard boxes were placed in areas with high paper generation (computer room, file room, print shop, reproduction area, etc.) for on-site storage.

The dual basket approach provided a second wastebasket for storage of source separated paper. High generation areas received one or more 15-to-55 gal containers in which to store separated paper.

The central container approach provided large containers (90 to 95 gal) throughout an office building for on-site storage.

On-Site Gathering

Mixed Waste. On-site gathering (or collection) of mixed waste from office buildings was performed in a similar manner at all case study sites. The basic process entailed custodians making daily rounds to gather residuals from each wastebasket in the building. Wheeled carts were used with drums, sacks, or bags attached to contain collected quantities. When filled, the drum/sack/bag was wheeled to the nearest waste receptacle or processing area, the contents emptied or the container detached and replaced by an empty, whereupon the custodian returned to the route. For high rise buildings, the preceding sequence was modified so that custodians left collected waste by the service elevator whereupon it was transported by a porter to the appropriate receiving area.

Time spent by custodians performing mixed waste collection activities prior to and after implementation of source separation programs is summarized below in terms of custodial time per day and custodial time per employee per month.

	Mixed Waste Collection Time			
	Range		Average	
	(hrs/day)	(hrs/employee/mo)	(hrs/day)	(hrs/employee/mo)
Prior to source separation	0.5-4.3	0.18-1.40	1.6	0.44
After source separation	0.5-3.7	0.12-1.05	1.4	0.35

the reduction in mixed waste gathering time shown in the preceding summary is directly attributable to paper removal. Less mixed waste results in fewer custodial trips to the waste receiving area unless waste and separated paper are collected simultaneously after implementation of a source separation program. In such instances, the number of trips should remain identical although total gathering time has the potential for increase based on four case study sites that implemented simultaneous collection systems:

Building Number	Source Separation Approach	On site gathering time (hrs/custodian/day) Prior to implementation (Mixed waste only)	After implementation (Mixed waste and separated paper)
2	Central container	1.0	1.0
4	Central container	0.5	0.5
5	Desk top	1.0	1.1
7	Dual basket	1.4	1.5

concluding that one source separation approach is more adaptable than another based on the preceding tabulation is not possible due to differences in participation rate, quantities collected, and building configuration. More important than ranking the respective approaches, however, is the fact that the incremental times were absorbed into ongoing custodial operations which is a key factor in optimizing source separation.

Separated Paper. Depending on source separation approach, varying amounts of labor and equipment are required to collect separated paper from desk top containers, dual baskets, or central containers (or a combination thereof), and to transport collected quantities to a central storage or processing area. Categorical approaches to accomplishing the collection/transport tasks are summarized below based on case study observations.

Desk top

Custodians collected separated paper from desk tops and/or central containers while on routine waste collection rounds. The paper, after quickly being reviewed for contaminants, was either stacked on a custodial cart shelf or in an extra sack or barrel

carried on the cart. When the mixed waste container filled, waste and recovered paper were simultaneously transported to a central storage area where the paper was placed in used corrugated boxes. Alternatives in this routine were (1) to drop full bags of paper in hallways for subsequent collection by another custodian with a large wheeled cart, and (2) to drop full bags of paper down a central waste chute to the storage area.

Mail delivery personnel collect paper from the desks and review for contaminants while making multi-daily deliveries. Collected paper was stored on the mail cart and transported back to the mail room and stacked in used corrugated boxes. Full boxes from the mail room and central containers placed in high generation areas were transported by custodians to the central storage area as required.

Part-time personnel were hired to perform the entire process: gathering paper from desk tops and central containers, reviewing for contaminants, and transporting paper to the central storage area.

Desk Basket

During normal daily waste collection, custodians empty the contents of the respective baskets into designated sacks or containers on custodial carts. When the mixed waste container filled, the cart was transported to a designated storage area where upon the paper sack was exchanged for an empty.

Each participant was responsible for emptying the basket designated for paper into one of many central containers, conveniently located throughout the facility. When full, central containers were transferred to a main storage location, emptied into larger storage containers, and returned to their original location.

Central Container

Custodians transport central containers to a main storage area while performing normal waste handling routines and return empty containers to replace those collected. Rather than transferring the entire container, custodians sometimes topped off the mixed waste barrel with paper from a central container and dropped off the paper at the appropriate storage area enroute to dump mixed trash.

In either instance, collection was generally provided according to generation rates with containers accepting heavy loads being serviced daily, and light generation points serviced at lower frequencies.

Table 12 shows that seven of the case study sites were able to use existing resources to collect paper; five programs integrated paper collection with custodial functions while one used mail distribution personnel and another used general service personnel. Of the five programs unable to absorb paper collection activities,* three required incremental custodial labor while one used part-time work-study students and another used personnel from a local social rehabilitation program. Tabulation by source separation approach is indicative that desk top and central container programs are more amenable to labor absorption than dual basket programs. This observation, however, is not substantiated by tabulating time requirements for collection of source separated paper (Table 13) although comparing categorical time requirements to diverted disposal rates reveals that the desk top and central container programs were more efficient than dual basket programs.

Approach	Collection Time (hr/employee/mo)	Diverted Disposal Rate (% of total waste)
Desk top	0.07	18
Dual basket	0.07	13
Central container	0.08	40

Processing

Mixed Waste. Mechanical processing of mixed wastes was performed at four case study locations. Bank Buildings No. 2 and 4), and the state government complexes (Buildings No. 1 and 5) shredded confidential material to destroy legibility. Therefore, shredding was not a processing technique integral with the waste management system. In fact, based on data from Building No. 5, shredded materials

* Contracted custodial service agreements required renegotiation to account for labor requirements associated with separated paper collection. Of the three case study sites with contractual service, one was able to circumvent incremental labor requirements by effectively using undertime of two general service employees, the other two accepted the additional labor as a condition for program implementation.

TABLE 19

LABOR UTILIZATION FOR PAPER COLLECTION

By Labor Category

Labor Category	Labor Utilization (no. persons)		
	Total By Category	Existing Resources	Incremental Requirements
Custodial	8	5	3
Clerical service	1	1	-
Mail distribution	1	1	-
Students	1	-	1
Rehabilitation	1	-	1
Total	12	7	5

By Source Separation Approach

Approach	Labor Utilization (no. persons)		
	Total By Approach	Existing Resources	Incremental Requirements
Desk top	1	1	-
Dual container	5	-	5
Central container	6	6	-
Total	12	7	5

TABLE 13

TIME REQUIREMENTS FOR COLLECTION
OF SOURCE SEPARATED PAPER

Approach/ Building Number	Collection Requirements (hr/employee/mo)		
	Time	Assorted	Incremental
Desk Top			
3	0.08	*	
6	0.06	*	
10	0.08		
Average	0.07	0.07	0.00
Dual Basket			
7	0.06	*	
9	0.06		*
11	0.03		
Average	0.05	0.05	0.00
Central Container			
1	0.07	*	
2	0.11	*	
4	0.23	*	
5	0.07	*	
8	0.07		*
12	*		
Average	0.08	0.10	0.02
Overall Average	0.08	0.08	0.01

*Not estimable.

was about three times less dense in a loose state than other paper waste and required correspondingly more time and space to handle.

Stationary compactors were used to densify mixed waste at Buildings No. 1, 10, and 12. For large waste generators, this processing technique lowers the requirement for waste collection frequency by private or municipal haulers.

A baler was used at one test (Building No. 6) to reduce storage space requirements resulting from company policy to retain office waste for ten days prior to disposal. Upon expiration of the retention period, the bales were scanned for contaminants that would restrict recycling as a low grade mix. Eighty percent of the bales were determined to be too contaminated and subsequently disposed.

Separated Paper. Source separated paper was manually and/or mechanically processed at five case study sites.

As previously stated, nine of the twelve programs studied opted to market employee separated paper with minimal or no secondary sorting. Significant post-employee sorting operations were, however, conducted at Buildings No. 7, 8, and 12 to improve marketability. These major efforts were designated as manual processing. Each of the three buildings used the central container approach. The mixed grade recovered through source separation was then sorted into specific grades by incrementally hired personnel. Although data from Building No. 12 were not amenable to analysis, approximately 10 to 20 hours were required to produce one ton of sorted paper at the other two sites.

Building Number	Sorting Time (person-hrs/ month)	Sorted Paper (tons/month)	Time Per Ton (hrs)
7	129	8.1	15.1
8	157	15.9	9.8

Mechanical processing of separated paper in the form of densification was performed at Buildings No. 1, 8, and 5. Buildings No. 1 and 8 both had central container programs to recover mixed high grades. As noted earlier, both buildings request employees to refrain from disposing of paper contaminants such as organic wastes and bottles in desk waste baskets.* At Building No. 1, the incentive was

* Based on representative sampling conducted at Building No. 1, employees adhered to the request as contaminants were found to be only one percent by weight.

reduced disposal costs realized by local mixed low grade dumped for use in the manufacture of roofing paper and wallboard. A stationary compactor was provided by a local paper dealer to density dust wastes.

The referenced ten-day retention period for office waste was the incentive for desiring to eliminate at least the organic fraction from dust waste at Building No. 5. A baler was used to density dust waste for retention after which 70 percent of the bales (75 lbs each) were sufficiently free of contamination to be marketed as mixed low grade.

Building No. 5 used a baler to density white ledger recovered via the desk top approach. Rationale for utilization of a baler was storage related. The agreement between Building No. 5 and the paper purchaser provided an economic penalty for transporting accumulated paper quantities less than 5 tons. Purchase of a baler minimized storage space as well as handling requirements during the period required to accumulate the minimum tonnage.

Central Storage

Mixed Waste. A wide variety of central storage approaches were utilized in case study locations. Compaction containers with from 10 to 40 cu yd capacities, roll-off containers with capacities ranging from 20 to 30 cu yd, bulk bins with capacities of 1 1/2 to 3 cu yd, and an open trash room. The amount of space required for mixed waste was dependent on many factors including waste generation rate, number of buildings/collection points in a complex, amount of paper separated, loose or densified waste storage, etc. Thus, meaningful comparisons cannot be drawn among buildings.

Separated Paper. Availability of space to store paper is critical to the successful implementation of a source separation program, especially when office building designers are prone to minimize the importance of mixed waste storage requirements, let alone separated paper requirements.

Central storage containers were provided by paper dealers at seven case study sites. Container types provided ranged from 55 gal drums to a 40 cu yd compaction container. Where buildings opted to market specific grades, individual containers were generally provided. In all seven instances, the containers were provided at no direct cost.

Until storage became a problem at Building No. 5 (whereupon baling was initiated), all three desk top programs used old corrugated boxes for central storage purposes. The boxes

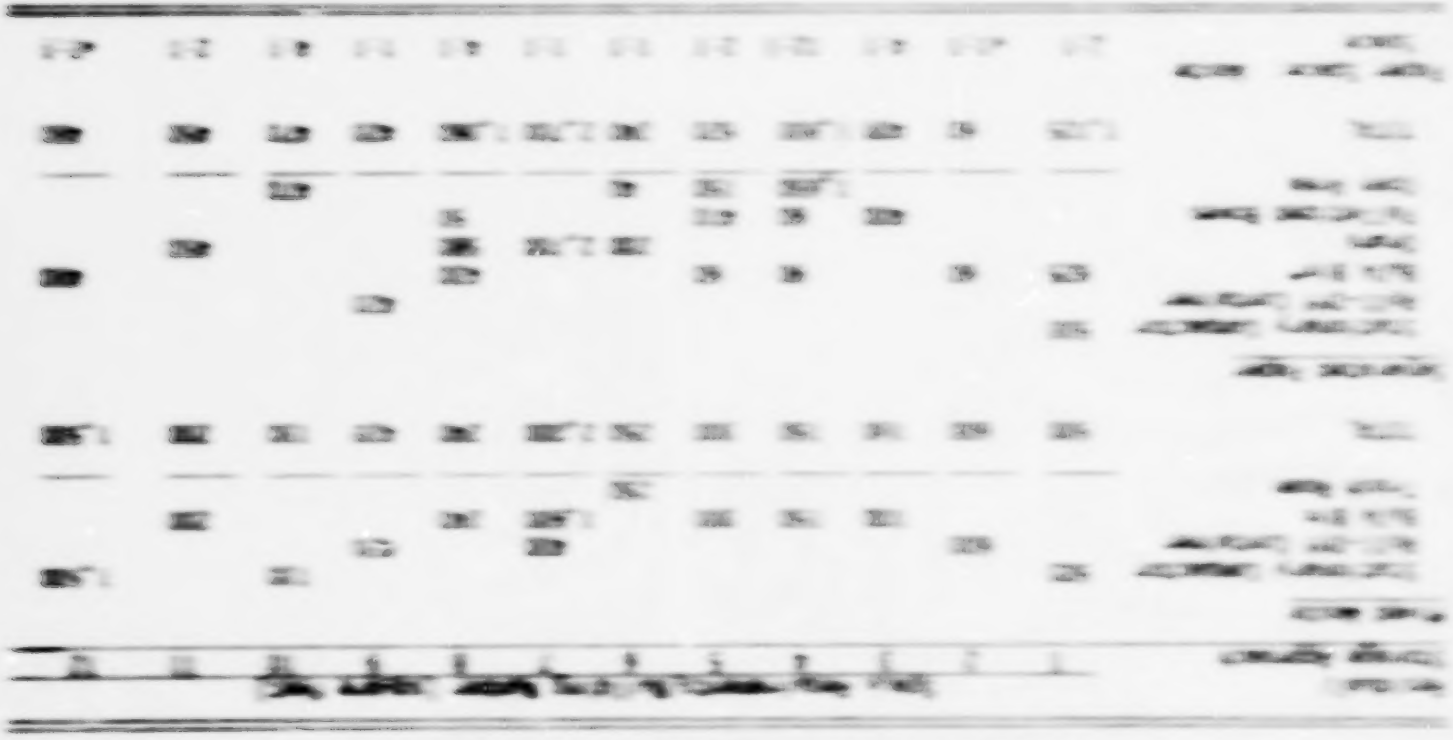
were stacked and tied on pallets for shipment. This procedure in effect avoided a portion of corrugated waste from disposal. Central storage containers were purchased or custom built at the remaining two case study sites.

Table 16 summarizes central storage space requirements for mixed waste and separated paper. The only meaningful interpretation that can be made from the data is with regard to the ratio of space consumed by separated paper to that by mixed waste. The ratio was equal or greater at over 80 percent of the locations studied. This trend is likely due to paper grade separation and associated mezzanine requirements needed to accommodate paper accumulations.

Transportation

Mixed Waste. Buildings No. 7, 8, and 11 provided their own service for mixed waste collection and hauling. All other case study sites received contracted or municipal service. Regardless, the transportation process entailed collection of mixed waste at regular intervals, and transporting the material to a local disposal site. Seven of the twelve case study sites reduced the number of bins required to store mixed waste and/or reduced collection frequency as a result of source separating paper.

Separated Paper. Separated paper was transported by the purchaser at each case study location. With the desk top approach, a service charge was levied for quantities under 1 ton at buildings No. 1, 2, and 10. Otherwise, frequency of collection varied from daily to every other week depending on agreements reached between the office building and the paper dealer.



IV

SOURCE SEPARATION ECONOMICS

[illegible] costs to start and operate an office building source separation program, as well as the economic impact on overall solid waste management are assessed in this section.

Methodology

Solid waste management cost data were gathered at each case study site to reflect costs prior to and after implementation of the source separation subsystem. As defined and exemplified below, these data were analyzed via two cost accounting methods:

> The incremental method attributes costs or savings to a source separation program only if they exceeded or reduced the budget for solid waste management prior to program implementation. For example, if paper collection requirements were absorbed within existing labor allocations, incremental costs were not attributed. Conversely, labor specifically hired to collect/sort separated paper and incremental equipment purchases were wholly attributed to the program.

> The fully allocated method attributes costs or savings to a source separation program on the basis of apportionment.[F] For example, collection of separated paper by specially hired personnel sometimes reduced the amount of custodial time spent collecting mixed waste. The fully allocated method would assign a cost to paper collection personnel and attribute a savings to reduced custodial time even if budgeted costs remained unchanged.

In addition to being the most practicable, the incremental cost approach was deemed by the research team and site

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F The only exception was the source separation effort by office personnel. Time to place separated paper in a desk top dual or central container was assigned to be no greater than 1 recording in a wastebasket.

study site personnel to be the most realistic indicator of expenses and/or savings accruable to a solid waste management system incorporating a source separation program. Thus, source separation economics presented in this section reflect this methodological approach.

Fully allocated costs are often valuable in illuminating such variables as labor commitments, but often distort true costs.[5] Readers interested in the fully allocated costs at each case study site may refer to the Appendix addendum for further discussion and individual estimates using this cost accounting procedure.

Startup Costs

Startup cost elements associated with source separation programs include administration, equipment, and labor.

Administration

As defined in Section III, initial program administration encompassed administrative and clerical efforts for planning and publicity/education. In general, the only out-of-pocket expenditures were for publicity/education materials which averaged three to four cents per employee. Although absorbed, the necessity for administrative planning cannot be underestimated. The average of three minutes per employee should be viewed as the minimum requirement to attain a viable program. A well conceived and planned program will minimize the amount of ongoing administrative effort.

Equipment

Incremental equipment and labor costs are summarized by source separation approach in Table 15.[6] Although site

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[5] For example, two laborers were specifically hired at Building No. 8 to collect source separated paper. As a result, custodial time to collect mixed waste was estimated to have been reduced by one-half of an hour per custodian per day. The custodial staff size and corresponding budget, however, remained unchanged. Attributing a cost savings of one-half of an hour per day to each of the 197 custodians employed at Building No. 8 would not be indicative of true program costs or savings.

[6] No trends were apparent when startup requirements were compared by type of building.

| | | |

specific and discussed below, the case study sites had initial out-of-pocket equipment expenses ranging from nothing at four locations to $16,000 at Building No. 8 (excluding Building No. 8, which individually accounted for nearly half of the total equipment expenditures at all case study sites, the average program incurred initial equipment costs of about $1,100. Restated in terms of median employment, incremental equipment costs averaged about one cent per employee.

Categorically, the desk top programs displayed the greatest ability to minimize incremental startup requirements. A baler and central paper storage containers were purchased at Building No. 5 to reduce storage space while accumulating 5 tons of paper prior to market transport. Of significant note is realization that all desk top containers were provided without direct cost by the paper purchaser. Also, storage containers were in the form of used corrugated boxes.

Dual basket programs generally incurred equipment expenses associated with paper collection. Building No. 7 had significant costs for custodial cart modification to accommodate paper collection and Building No. 8 required a half-ton van to collect aggregated paper quantities. (Building No. 11 acquired a van at no cost to similarly collect paper.) Building No. 6 also incurred substantial costs for central containers and customized central storage bins.

Central container programs generally had startup expenses associated with the central containers. Typical central containers purchased were metal or plastic, ranging in capacity from 20 to 80 gal. A baler was purchased at Building No. 4 to reduce office waste storage space which had potential marketability after a policy oriented 10-day retention period expired. Building No. 12 incurred a small expense to modify several custodial carts.

Labor

Incremental labor requirements were site specific. As a proxy for initial out-of-pocket costs, Table 15 shows the monthly cost for incrementally hired personnel. As shown, seven sites incurred incremental labor costs ranging from $66 to $2,811 per month. Due to the variable nature of the incremental labor requirements, averages are not meaningful.

The desk top programs displayed the greatest ability to absorb collection labor requirements. Building No. 10 used two part-time work-study students to collect separated paper

Incremental collection labor was required at two of the three dual basket programs where custodial workloads were deemed incapable of absorbing a separate paper collection task. Building No. 8 hired two full-time laborers to collect separated paper from throughout the 16-building complex. Similarly, a full-time project coordinator was responsible for collecting separated paper throughout the 70-building complex at Building No. 11. Building No. 7, which comprised 18 individual buildings, was able to absorb the paper collection function with the existing custodial staff.

Incremental labor was required at four of the six central container programs. Building No. 2 used part-time hires to sort separated paper into specific grades. Similarly, Building No. 4 hired two full-time laborers to sort paper. The custodial contract at Building No. 9 was increased by two person-hours per day to cover additional time spent collecting separated paper. Labor at Building No. 12 for paper collection and sorting was from a social rehabilitation program.*

Operating Costs

Analysis of all operating costs affecting solid waste management (equipment, labor, administration, disposal, paper revenue) before and after source separation implementation was performed to assess program viability.

The site specific nature of incremental equipment and labor costs referenced in the preceding startup cost discussion carried over into operating costs. The equipment costs shown in Table 15 were assumed to be depreciated on a straight-line basis over a five-year period. As such, incremental equipment operating costs induced by source separation ranged from nothing at four sites to almost $500 per month at Building No. 8. By again assuming Building No. 8 equipment expenditures to be inordinately high, the eleven other programs incurred incremental equipment operating costs ranging from zero to $60 per month with an average of about $20 per month.

Incremental labor operating costs were used as a proxy for startup costs. Reference should be made to the preceding discussion of labor startup costs.

Incremental administrative costs were limited to ongoing costs for publicity/education materials, administration/

* Building No. 12 paid one-third of the personnel cost; the remaining portion was paid through State and Federal funds.

clerical labor requirements and costs were absorbed within existing workloads.

Reduction of waste disposal costs was again site specific. Seven sites were able to reduce the number and size of storage containers and/or reduce collection frequency. In such instances a diverted disposal savings accrued. Five sites accrued no disposal savings for one or more of the following reasons:

Insignificant waste reduction.

Local health regulations required a minimum collection frequency where putrescible cafeteria wastes were included with office residuals.

Multiple buildings at a single site required a bin of minimum size placed at each building to minimize custodial dumping efforts. Waste reduction at each building did not affect collection requirements.

Revenue from sales of source separated paper served to defray/cover incremental operating costs. Table 14 summarizes typical revenues received by each case study site for specific grades separated. There are several notable observations with respect to the tabulation. With the exception of Building No. 9, all case study sites with computer facilities kept tab cards separate from other grades. Computer printout was generally included with white ledger (bond, reproduction paper, etc.) except at Buildings No. 8 and 12 where additional employees were hired to sort recovered quantities into specific grades. The notable decline in low grade sales price in conjunction with the relative quantities generated (refer to Table 5) make low grades questionable for economical recovery. The same consideration applies to colored ledger.

Program Economics

Analysis of collection and disposal costs before and after implementation of source separation programs revealed that nine of the twelve case study sites were able to effectively lessen solid waste management costs through source separation. In terms of percent change, the net costs ranged from a decrease of 35 percent to an increase of 7 percent with an overall average decrease of 12 percent. Categorical assessments are made below on the basis of

[illegible]

building type, source separation approach, and grade(s) of paper marketed.

Office Building Type

Table 17 summarizes the impact of source separation on overall solid waste management costs on the basis of building type.

Although incremental collection costs were generally highest at banks and insurance companies, the impact of source separation was generally greatest due to large sums of readily separable high grade wastepaper. Two interrelated factors affected program economics at Building No. 2: (1) source separation was implemented in a portion of the office complex only, (2) the cost for a part-time hire to sort was excessive of disposal and revenue savings. Revenue and disposal savings exceeded incremental costs by 28 to 35 percent at each of the three other buildings.

Four of the five general office buildings reduced overall solid waste management costs by 7 to 25 percent. The inability of paper revenue (mixed grade) and diverted disposal savings to overcome incremental equipment and labor costs at Building No. 3 resulted in a two percent increase.

Source separation had the least impact on costs at multi-disciplined buildings. While two of the three programs achieved cost reduction, Building No. 11 was not able to overcome the incremental requirement of paper collection labor by marketing a mixed grade. Due to the relatively small quantities of solid waste diverted by the multi-disciplined buildings (average of 11 percent) none of the programs accrued disposal cost savings.

Source Separation Approach

Table 18 presents the impact of source separation on overall solid waste management costs based on approach.

As shown, the desk top programs effectively reduced solid waste management costs from 8 to 35 percent with an average of 21 percent. Categorically, the desk top approach was the only system whereby revenue alone exceeded incremental collection costs. That is, diverted disposal savings were not required to be 'profitable'. This is an important consideration, especially to commercial/agencies occupying leased buildings whereby diverted disposal savings revert to the building owner.

[illegible]

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two of the three dual basket programs effectively increased overall solid waste management costs by 7 and 7 percent, while the third program reduced overall costs by 9 percent. The two programs experiencing cost increases (Buildings No. 8 and 11) were unable to cover incremental collection costs through marketing a mixed grade of paper. Conversely, Building No. 7 was able to market a mixed grade and reduce overall costs because collection functions and costs were absorbed.

Overall, central container programs effectively reduced solid waste management costs by an average of 17 percent. Five of the six programs experienced cost reductions ranging from one to 37 percent while Building No. 3 had a cost increase of five percent due to sorting costs exceeding revenue and diverted disposal savings.

Paper Grade

Table 19 summarizes the economic impact of source separation in terms of paper grade(s) marketed.

The two case study sites in the "white, colored, mixed" category each source separated high grade mixed and marketed unseparated "desk waste" as a low grade mix. As previously discussed, desk waste contaminant control was accomplished by restricting employees from eating at their desks. This systematic approach reduced solid waste management costs by an average of 10 percent. Also of significance is the observation that the cost for two full-time sorters at Building No. 4 was exceeded by the revenue from high grade separation.

Programs skimming white paper only (all desk top) achieved cost reductions ranging from 8 to 35 percent, with an average reduction of 21 percent.

Categorically, "white and colored" programs marginally lowered solid waste management costs. Building No. 6 achieved a seven percent cost reduction by marketing white and colored paper in the employee separated condition. Both of the other two programs in this category sorted employee-separated paper into specific grades. Building No. 9 was unable to recover the sorting cost through revenue. Building No. 12 was able to achieve a marginal reduction due to paying only one-third of sorting personnel wages (remainder paid through a social rehabilitation program).

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

the 'mixed only' grade provides the lowest revenue of the market categories considered. Buildings No. 8 and 11 were unable to recover the cost of supplemental paper collection personnel hired on a full-time basis. Building No. 7, which absorbed the paper collection function, and Building No. 9, which accepted a minor contract increase for paper collection, were able to implement a source separation program while achieving overall cost reductions of seven and nine percent, respectively.

OPTIMIZATION ANALYSIS

Results of case study analyses were indicative of economic stability of source separation in office buildings. As noted throughout the report, however, variations existed in implementation approaches and schemes, personnel and equipment requirements, paper market values, etc. Thus, an analysis to assess optimal impact of source separation with respect to overall solid waste management costs in a hypothetical general office building is presented in this section. The analysis was performed under controlled conditions using relevant data and/or inferences from the case study sites, and assuming observed practices and operations typify the "state-of-the-art." Accordingly, comparisons were made of four alternative source separation schemes:

- Scheme 1: Source separation of white paper grades via three alternative approaches: desk top, dual basket, and central container. In each instance computer tab cards were assumed to be manila and kept separate from computer printout and white ledger of which the latter two grades were jointly marketed as white ledger.
- Scheme 2: Source separation of mixed high grade via the optimum approach determined from the Scheme 1 analysis. Computer tab cards were assumed to be independently separated.
- Scheme 3: Source separation of mixed low grade via the optimum approach determined from the Scheme 1 analysis. Computer cards were assumed to be independently separated.
- Scheme 4: Source separation of all recyclable paper (i.e., mixed low grade) via the optimum approach determined from the Scheme 1 analysis with secondary sorting into specific grades for marketing. Computer tab cards were assumed to be independently separated.

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Data Development

Evaluation of the alternative source separation schemes required estimating waste generation and composition and assessing five cost elements: labor, equipment, overhead, disposal, and savings.

Waste Generation/Composition

The hypothetical general office building analyzed was assumed to have housed 1,000 employees, the median employment at the case study sites. Total solid waste generation for the hypothetical building was estimated at 30 tons per month based on the average general office building generation rate shown in Table 4.

Waste composition for a general office building was derived from Table 5. The recoverable portion of each paper type was adjusted using the average employee participation rate for alternative source separation approaches* as a proxy. Available and adjusted quantities are shown below.

Paper type	Paper Available (tons/mo)	Recoverable portion (tons/mo) Desk top	Dual basket	Central container
Computer tab cards	1.0	0.9	0.9	0.9
Computer printout	6.1	1.8	1.8	1.8
White ledger	9.9	6.9	7.1	7.1
Colored ledger	1.0	1.6	1.1	1.4
Corrugated	4.7	4.4	1.9	2.1
Newspaper	4.9	4.4	1.5	1.8

Labor

Custodial labor was used on a daily basis to collect and transport discarded office waste to a central storage location. In the hypothetical building, 18 custodians were assumed to have been required based on the median case study ratio of one custodian for each 100 employees prior to source separation implementation. Again based on case study data, custodians were assumed to have spent 1.6 hours per day to fulfill solid waste oriented functions. Average custodian wages averaged about five dollars per hour including fringe benefits.

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* Desk top, 90 percent participation; dual basket, 72 percent; and central container, 79 percent.

labour to collect source separated paper was absorbed at some case study sites, incremental at others, and varied by separation approach. Incremental paper collection tasks were assumed to have been conducted by custodians at the following rates:

Source Separation Approach	Incremental Paper Collection Requirements (hours per day)
Desk top	0.1
Dual basket	0.9
Central container	0.1

Sorting mixed grades of source separated paper into specific grades at the case study sites typically required 10 hours to produce one ton of sorted paper. Sorters received burdened wages of about four dollars per hour.

Equipment

Based on a five-year straight line depreciation, the average cost for such equipment as wastebaskets, custodial carts, plastic bags, etc., averaged 10 cents per employee per month, or $180 per month for the hypothetical building. Incremental costs for equipment required to implement a source separation program varied by approach. For example, desk top containers were assumed to be supplied at no direct cost; dual basket programs generally experienced custodial cart modification costs and/or costs for containers; central container programs generally incurred costs for the central containers themselves. Assuming processing, i.e., baling of separated paper not to be performed, the average incremental equipment costs are summarized below:

Source Separation Approach	Incremental Equipment Cost ($/mo)
Desk top	2
Dual basket	32
Central container	21

Overhead

Overhead expenses for administration, building, and land were assumed to be five percent of equipment and labor costs.

Disposal

Disposal of solid waste averages $27 per ton at the case study sites.

Savings

Solid waste management cost savings due to source separation can accrue as a result of diverted disposal and/or revenue from the sale of separated paper.

Disposal savings. Disposal savings are generally not reduced proportionally to waste quantities diverted.* For example, the amount of paper diverted from disposal averaged 34 percent by weight at the case study sites, while disposal costs were reduced by an overall average of 18 percent; or, monetary savings were about half of the disposed quantity reduction when both factors are expressed as percentages. This factor was used as a proxy for diverted disposal savings in the optimization analysis.

Revenue. The following paper stock prices typify prevailing markets and were used in the assessment:

Paper grade	Market price† ($ per ton)
Computer tab cards	100
Computer printout	60
White ledger	50
Colored ledger	25
Corrugated	10
Newspaper	10
Mixed low grade	5

* If the building is rented or leased, diverted disposal savings will likely not accrue to the occupant as would be the case if the occupant was also the building owner. For the purposes of this analysis, the hypothetical building was assumed to be owned by the occupant which was the condition at 10 of the 12 case study sites.

† Prices on the basis of a dealer providing necessary central storage containers and transportation.

Optimization Analysis Results

Table 20 summarizes the analysis of the alternative approach/schemes.*

Optimum Approach

Each of the approaches analyzed in Scheme 1 effectively lowered overall solid waste management costs. The desk top approach proved to be more economical than the dual basket or central container approaches.

Alternative Source Separation Approach	Collection and Disposal Cost Prior to Implementation of Source Separation ($/ton)	Collection and Disposal Cost After Implementation of Source Separation ($/ton)	% Change
Desk top	155	119	-23
Dual basket	155	127	-18
Central container	155	122	-21

Optimum Scheme

Using the desk top approach, each of the four separation schemes effectively reduced overall solid waste management costs in the analysis. Separation of white high grade paper, however, proved to be more economical than separating a high grade mix or a low grade mix, with or without secondary sorting.

Alternative Source Separation Scheme	Collection and Disposal Cost Prior to Implementation of Source Separation ($/ton)	Collection and Disposal Cost After Implementation of Source Separation ($/ton)	% Change
1 (White high-grade only)	155	119	-23
2 (Mixed high-grade only)	155	125	-19
3 (Mixed low-grade)	155	129	-17
4 (Mixed low-grade/ sort)	155	141	-9

* Detailed backup to Table 20 appear in Appendix B.

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Contributing Factors	Prior to Source Separation	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Labor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Equipment	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Overhead	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Insurance	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Paper Revenue	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Solid Waste Management Costs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Solid Waste Generation (tons/hh)*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net Cost per ton (/ton)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* Total generation held constant for multiple comparison.

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ACKNOWLEDGEMENTS

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Donaldson Company, Inc.
National Bureau of Standards
New Jersey Bell
Oregon State Capitol
Safety Insurance Company
University of Oregon
Washington State Capitol
Wells Fargo Bank
Western Electric
World Trade Center

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In addition we wish to express our sincere gratitude to Trade Information Systems, Inc. for coordinating case study visit arrangements with representative companies/agencies using the data top system.

* One company requested total anonymity as a prerequisite for serving as a case study site. We respect their desires and acknowledge their participation in the study.

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APPENDICES

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B	Cost Data for Optimization Analysis	B-1

APPENDIX A

PAPER STOCK DEFINITIONS/HISTORIC PRICES

Introduction

Price information for five paper stock grades typically found in office buildings was obtained from Official Board Markets for the period encompassing 1970 through 1975:

1. Manila tab cards
2. Sorted white ledger
3. No. 1 News
4. Corrugated containers
5. No. 1 Mixed

Paper stock prices are given per short ton board mill prices, F.O.B. trucks, cars at dealers' or producers' plant exclusive of delivery, premium or distress lots, special packing, or other special charges. Grades are defined in current Paper Stock Standards and Practices, Circular #13 as published by the Paper Stock Institute of America, National Association of Recycling Industries, Inc.

Four representation areas were selected to represent a cross-section of the nation and to plot historical price ranges:

Geographical Area	Representative Market
East	New York
Mid-west	Chicago
South	Houston*
West	Los Angeles

Manila Tab Cards

Definition: Manila tabulating cards consist of printed manila-colored cards, predominantly sulphite or sulphate, which have been manufactured for use in tabulating machines. This grade may contain manila-colored tabulating cards with tinted margins.

* Official Board Market listing

Acceptable Contamination Level:

Prohibitive materials[1] : none permitted

Total outthrows[2] : may not exceed 1%

Price History: Table A-1 presents Manila Tab Card price fluctuations from 1970 through 1975. Prices remained relatively stable at $75 to $95 per ton until 1973 when the market rose sharply and peaked in mid-1974 at $200 to $250 per ton. By early 1975 prices had fallen to $125 to $150 per ton. At year end, manila tab card prices had risen to $170 to $190 depending on geographical area.

Sorted White Ledger

Definition: No. 1 sorted white ledger consists of printed or unprinted sheets, shavings, and cuttings of white sulphate ledger, bond, writing, and other papers which have similar fibre and filler content. This grade must be free of treated, coated, padded, or heavily printed stock (typical examples of acceptable office paper include letterheads, including tissue copies; Xerox or IBM copies; business forms; stationery; and typing paper. Higher grades such as manila tab cards and computer printout may also be included).

Acceptable Contamination Level:

Prohibitive materials: none permitted

Total outthrows: may not exceed 2%

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[1] Prohibitive materials: (a) Any materials which by their presence in a packing of paper stock, in excess of the amount allowed, will make the packing unsuitable at the grade specified.

[2] Outthrows: Outthrows shall be understood to be all papers that are so manufactured or treated or are in such form as to be unsuitable for consumption at the grade specified.

Price History: Table A-2 summarizes sorted white ledger price history from 1970 through 1975. From 1970 through 1972 sorted white ledger prices remained constant between $35 and $50 per ton. Prices began rising in early 1973 and peaked in 1974 at a range of $100 to $160 per ton. Peak prices generally held for about eight months and then declined to the present level of $80 to $85 per ton which is $35 to $50 per ton higher than 1970 prices.

No. 1 News

Definition: Consists of baled newspapers containing less than 5% of other wastepapers.

Acceptable contamination level:

Prohibitive materials - may not exceed 1/2 of 1%.

Total outthrows - may not exceed 2%.

Price History: As shown in Table A-3, No. 1 news generally oscillated between $10 and $22 per ton from 1970 to mid-1973. Prices rose sharply during the ensuing year, peaking at a price range of $35 to $60 per ton. From peak prices, the No. 1 news market plummeted and bottomed out at a low of $5 per ton. Late 1975 market prices have rebounded to 1970 price levels.

Corrugated Containers

Definition: Consists of baled corrugated containers having lining of either jute or kraft.

Acceptable contamination level:

Prohibitive materials - may not exceed 1%.

Total outthrows - may not exceed 5%.

Price History: Table A-4 presents corrugated container price history from 1970 through 1975. Prices generally ranged from $20 to $25 per ton between 1970 and 1971 whereupon prices rose to a range of $40 to $60 per

ton by early 1974. Thereafter, prices fell to historic lows during the period studied with a corresponding range of $8 to $25 per ton.

No. 1 Mixed

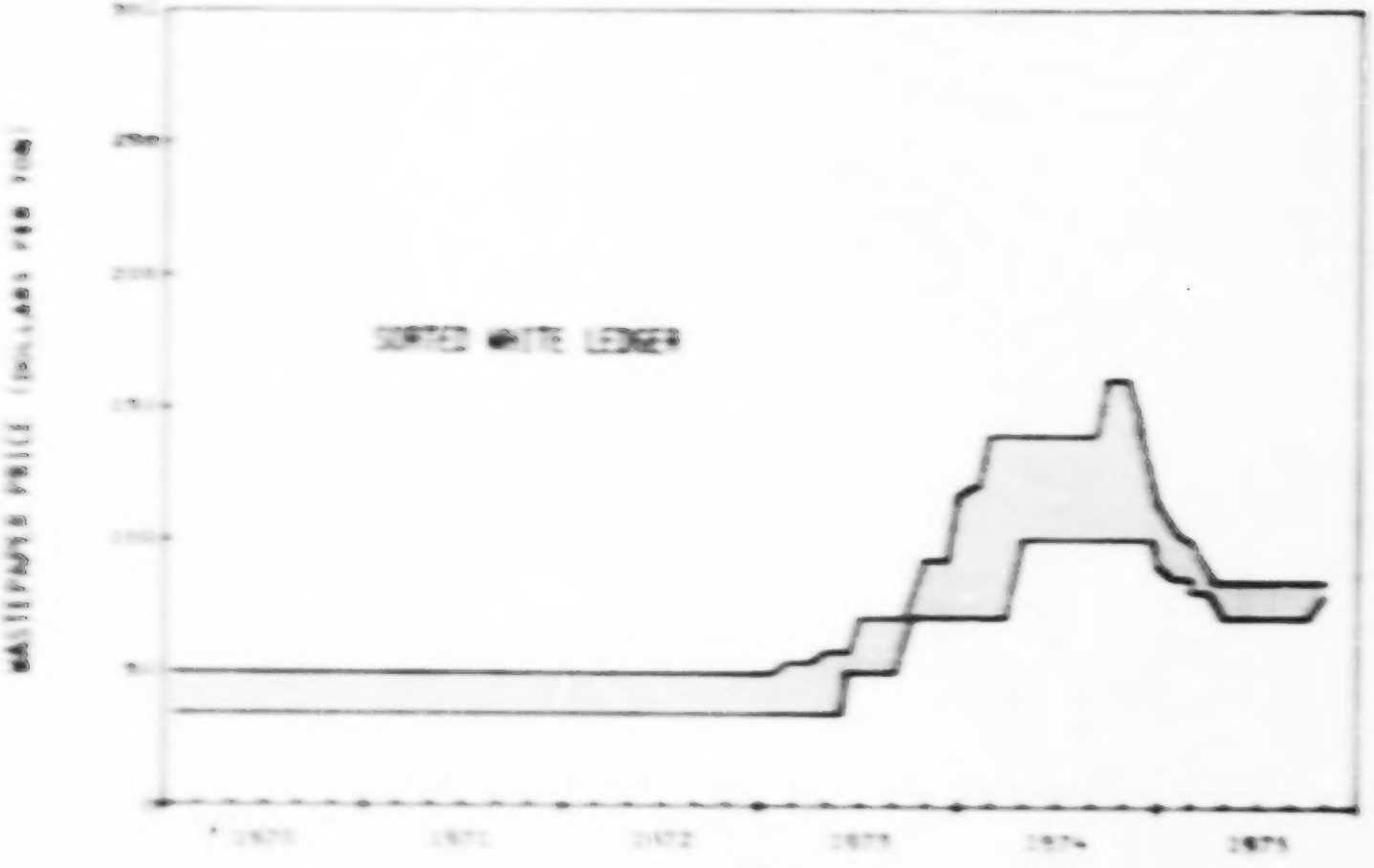
Definition: No. 1 mixed consists of a baled mixture of various qualities of paper containing less than 25% of groundwood stock coated or uncoated.

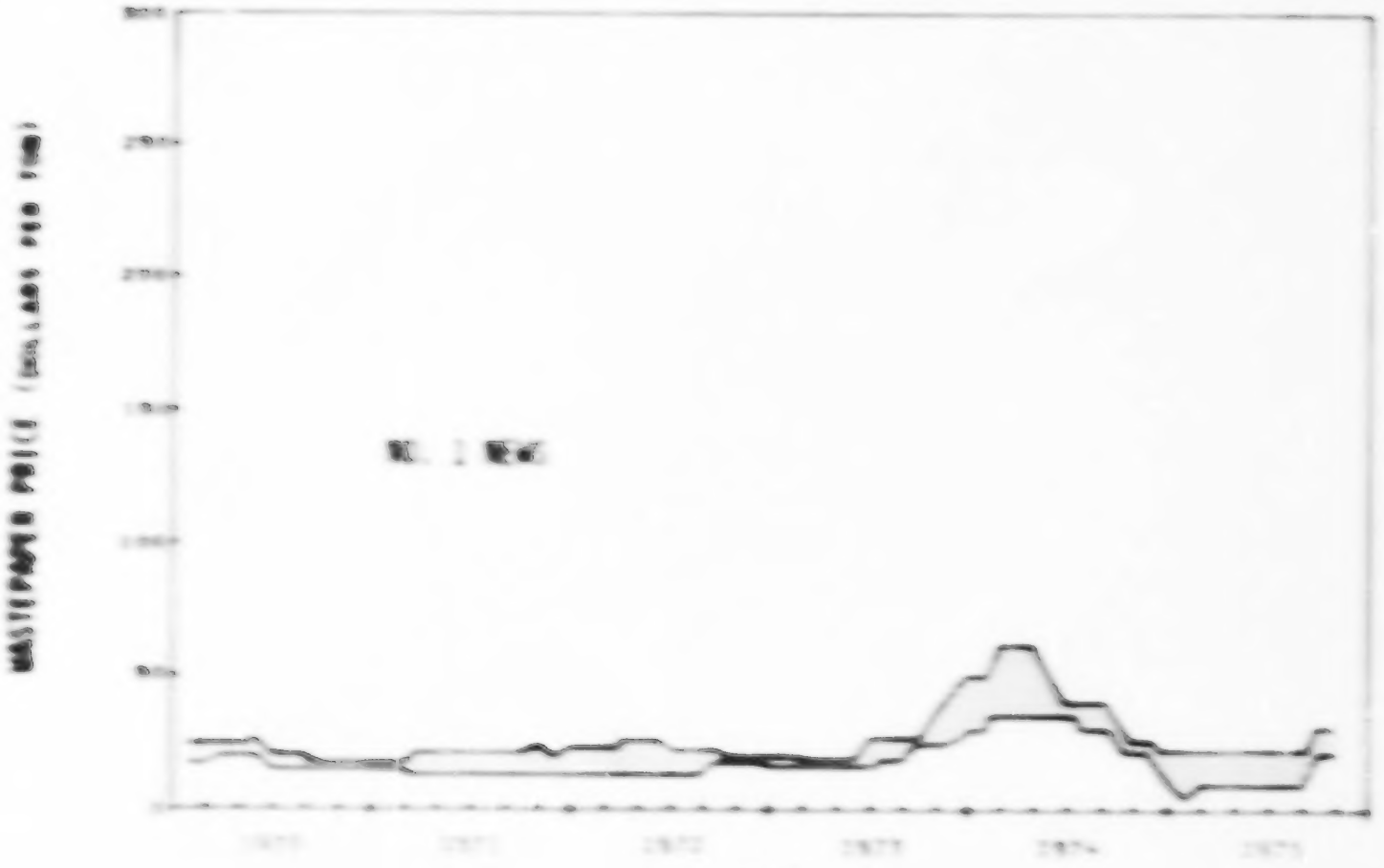
Acceptable Contamination Level:

Prohibitive materials - may not exceed 1%

Total outthrows - may not exceed 5%

Price History: No. 1 mixed historic prices from 1970 through 1975 are presented in Table A-5 with the exception of a price dip in 1971, No. 1 mixed had market values ranging from $10 to $18 per ton from 1970 to mid-1973. Prices rose for a ten month period and peaked in early 1974 at a range of $18 to $60 per ton whereupon values subsided to lows paralleling 1971. Late 1975 prices ranged from $5 to $18.





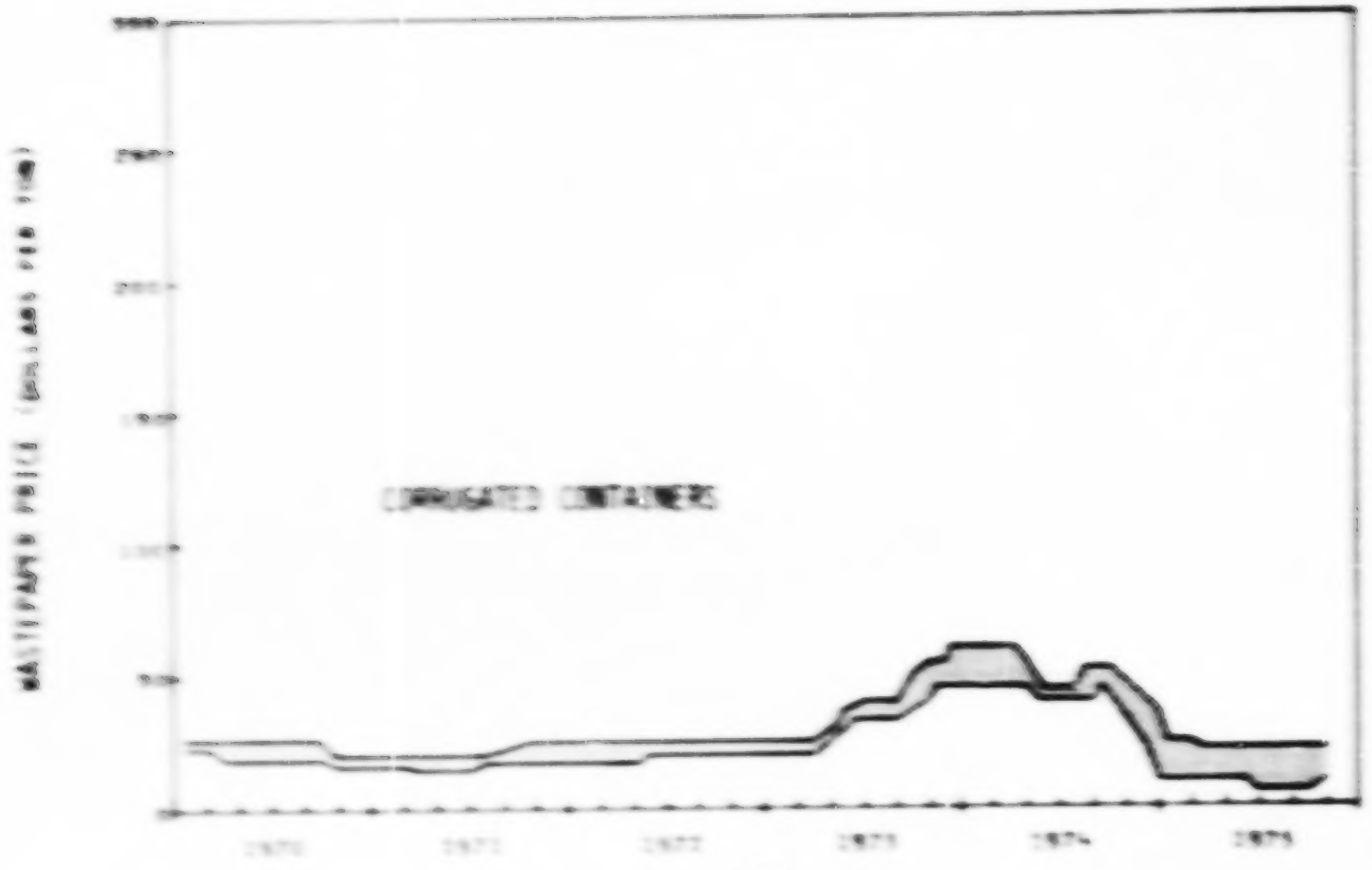


FIGURE 4-4

HISTORICAL CORRUGATED CONTAINER PRICES

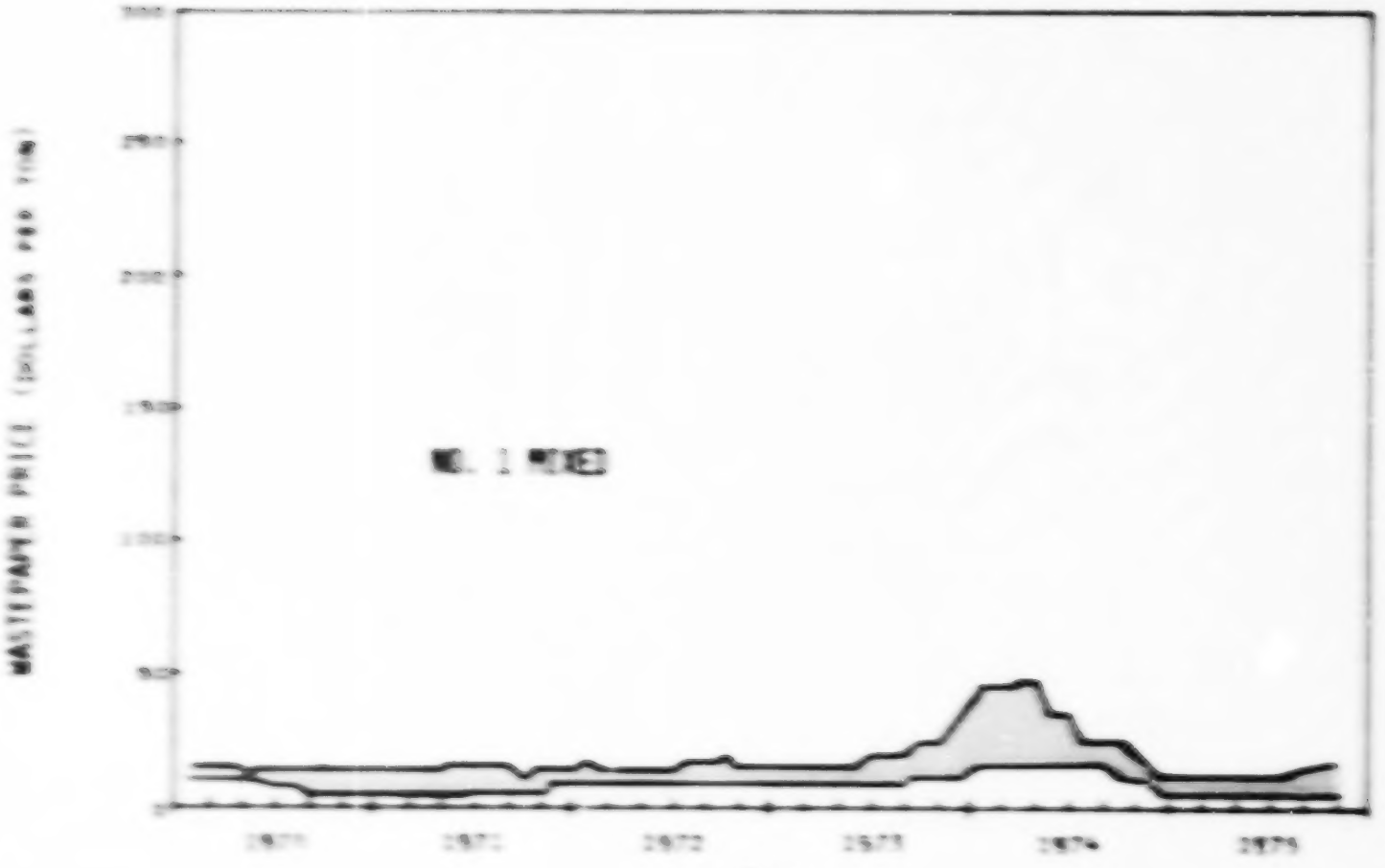


FIGURE A-1

HISTORICAL W. I PRICES

APPENDIX B

COST DATA FOR OPTIMIZATION ANALYSIS

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